

WHAT IS CLAIMED IS:

1 1. A driver circuit for an ultrasonic transducer, comprising:
2 a current sense circuit coupled to detect a transducer load current;
3 a controller coupled to the current sense circuit and configured to
4 perform a frequency sweep of a driver output to locate a resonance frequency
5 corresponding to peak current;
6 a voltage-controlled oscillator (VCO) coupled to the controller and
7 configured to generate an output signal oscillating at the resonance frequency; and
8 a pulse width modulator coupled to the VCO and configured to
9 modulate an output current of the driver circuit.

1 2. The driver circuit of claim 1 further comprising a first switch and
2 a second switch coupled to the pulse width modulator and configured to switch an
3 amount of the output current in response to the VCO output signal.

1 3. The driver circuit of claim 2 further comprising an analog-to-
2 digital converter coupled between the current sense circuit and the controller, and
3 configured to convert an analog output signal of the current sense circuit into a digital
4 signal.

1 4. The driver circuit of claim 3 further comprising a digital-to-
2 analog converter coupled between the controller and the VCO, and configured to
3 convert a digital controller output signal to an analog voltage signal.

1 5. The driver circuit of claim 1 wherein the current sense circuit
2 comprises:
3 a current sense resistive element magnetically coupled to the transducer;
4 a low pass filter coupled to the current sense resistive element; and
5 a full-wave rectifier coupled to the low pass filter and configured to
6 generate a DC signal representing the transducer load current.

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1 11. The driver circuit of claim 10 wherein the pulse width modulator
2 is configured to generate a first pulse width modulated signal PWM1 coupled to a gate
3 terminal of first field effect transistor switch, and a second pulse width modulated
4 signal PWM2 coupled to a gate terminal of second field effect transistor switch,
5 wherein the signals PWM1 and PWM2 are non-overlapping pulses.

1 12. The driver circuit of claim 11 wherein the pulse width modulator
2 generates signal PWM1 at one of a rising or falling edge of the output signal of the
3 VCO, and generates signal PWM2 at the other one of the rising or falling edge of the
4 output signal of the VCO.

1 13. A method for driving an ultrasonic transducer, comprising:

- 2 (a) sweeping a transducer frequency profile to locate a peak load
3 current;
4 (b) defining a reference frequency as the frequency corresponding to the
5 peak current;
6 (c) adjusting an oscillation frequency of an oscillator to the reference
7 frequency;
8 (d) controlling output transistor switches by pulse width modulated
9 signals generated in response to the oscillator output to adjust transducer current; and
10 (e) periodically repeating steps (a) through (d) to dynamically adjust the
11 reference frequency that controls the transducer current.

1 14. The method of claim 13 wherein the step of sweeping the
2 transducer frequency profile comprises an initial round of multiple frequency sweeps
3 with increasing granularity.

1 15. The method of claim 14 wherein the step of sweeping the
2 transducer frequency profile comprises:

3 performing a first broad frequency sweep using a first frequency step to
4 locate a first approximate peak frequency f_1 ;

5 performing a second medium frequency sweep using a second frequency
6 step that is smaller than the first frequency step, the second medium frequency sweep
7 being centered around frequency f_1 and yielding a peak frequency f_2 ; and

8 performing a third fine frequency sweep using a third frequency step
9 that is smaller than the second frequency step, the second third fine frequency sweep
10 being centered around frequency f_2 and yielding a peak frequency f_3 .

1 16. The method of claim 13 wherein the step of sweeping the
2 transducer frequency profile comprises a mid-operation sweep centered around the
3 reference frequency.

1 17. The method of claim 13 wherein the step of controlling output
2 transistor switches comprises generating non-overlapping pulse-width modulated
3 signals.

1 18. An ultrasonic system comprising:

2 an ultrasonic transducer; and

3 a driver circuit coupled to the ultrasonic transducer, wherein the driver
4 circuit comprises a microprocessor controlled phase-locked loop that is configured to
5 periodically sweep a frequency profile of the transducer to locate and lock onto a
6 resonance frequency, and to control a current of the transducer by pulse width
7 modulated current switches.

1 19. The ultrasonic system of claim 18 wherein the driver circuit
2 comprises a current sensor magnetically coupled to the transducer and configured to
3 detect transducer current.

1 20. The ultrasonic system of claim 19 wherein the driver circuit
2 further comprises a voltage-controlled oscillator (VCO) coupled to the microprocessor
3 and configured to generate an output signal oscillating at the resonance frequency in
4 response to a control signal from the microprocessor.

1 21. The ultrasonic system of claim 20 wherein the driver circuit
2 further comprises a pulse-width modulator coupled to the VCO and configured to
3 generate non-overlapping pulse width modulated signals in response to the VCO
4 output signal.

1 22. The ultrasonic system of claim 18 further comprising a container
2 for receiving energy from the transducer, the container having a chamber for holding a
3 liquid containing cells or viruses to be lysed, and the chamber having a least one wall
4 providing an interface between the transducer and the contents of the chamber.

1 23. The ultrasonic system of claim 22 wherein the transducer is
2 directly coupled to the chamber wall.

1 24. The ultrasonic system of claim 22 wherein the transducer is
2 coupled to the chamber wall via a horn, the horn having a vibrating tip for deflecting
3 the chamber wall.

1 25 . The method of claim 13, wherein the transducer is driven to lyse
2 cells or viruses held in a container by coupling the transducer to a wall of the
3 container and sonicating the chamber.

1 26. The method of claim 25, wherein the transducer is coupled to the
2 wall of the sample container via a horn.

1 27. The method of claim 25 wherein the transducer is directly
2 coupled to the sample container.